LWG
LOWER WILLAMETTE GROUP

PORTLAND HARBOR RI/FS
ROUND 1 SITE CHARACTERIZATION SUMMARY REPORT

DRAFT

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Submitted to:
Lower Willamette Group

Submitted by:
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LIST OF ACRONYMS

ADCP	acoustic doppler current profiler
CAS	Columbia Analytical Services
COC	chemicals of concern
CRD	Columbia River datum
CSM	conceptual site model
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DEA	David Evans Associates
DEQ	Oregon Department of Environmental Quality
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FSP	field sampling plan
FL	fillet with skin and belly flap
FOD	frequency of detection
FS	skinless fillet
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometer
HHRA	human health risk assessment
HPAH	high molecular weight polycyclic aromatic hydrocarbons
ICP-MS	inductively coupled plasma-mass spectrometry
ICP-OES	inductively coupled plasma-optical emission
ISA	initial study area
IUPAC	International Union of Pure and Applied Chemistry
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
LDC	Laboratory Data Consultants, Inc.
LPAH	low molecular weight polycyclic aromatic hydrocarbons
LWG	Lower Willamette Group
LWR	lower Willamette River
MC	Multnomah channel
MDL	method detection limit
MRL	method reporting limit
MS/MSD	matrix spike/matrix spike duplicate
NOAA	National Oceanographic and Atmospheric Administration
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
QA	quality assurance
QAPP	quality assurance project plans
QC	quality control
RI/FS	remedial investigation/feasibility studies
RM	river mile
RPD	redox potential discontinuity

SEA	Striplin Environmental Associates. Inc.
SCRA	site characterization and risk assessment
SIM	selective ion monitoring
SOP	standard operating procedure
SVOC	semivolatile organic compound
TEQ	toxicity equivalent
TOC	total organic carbon
VOC	volatile organic compound

1.0 INTRODUCTION

This Round 1 Site Characterization Summary Report presents the data collected by the Lower Willamette Group (LWG) during the Round 1A and Round 1 field activities (hereafter referred to as Round 1) for the Portland Harbor remedial investigation and feasibility study (RI/FS). Field activities for these sampling rounds took place in the summer and fall of 2002, and other data collection activities occurred through June 2004 (i.e., sediment stake monitoring and bathymetric surveying). The Round 1 Field Sampling Report, detailing the Round 1 sample collection and handling procedures, was submitted previously to the U.S. Environmental Protection Agency (EPA) on March 14, 2003 (SEA et al. 2003).

The required content of this site characterization summary report is specified in the EPA-approved Portland Harbor RI/FS Programmatic Work Plan (Work Plan) (Table 6-1; Integral et al. 2004), where the purpose of the report is described as

> Provides validated sample analysis results in tabular format. Provides chemical concentration maps showing the distribution of sample analysis results for selected [chemicals of interest] COIs. Data validation reports and a summary of data validation results also will be included in each site characterization summary report. [Exposure point concentrations] EPCs for human health will be submitted as interim deliverables with site characterization summary reports.

This report summarizes the data collection activities and describes the laboratory analyses, data validation, and data management procedures used to generate the Round 1 physical [e.g., bathymetry, acoustic doppler current profiler (ADCP) surveys)], sediment and tissue chemistry, and biota (benthic infauna) data. All Round 1 sediment and tissue chemistry data are summarized in tables, and selected results are geographically depicted on maps.

This Round 1 Site Characterization Summary Report consists of four sections and six appendices. The remaining sections of this report include the following information:

Section 2: Data Collection Activities. Section 2 summarizes the main objectives and methodologies used in the physical system studies (bathymetry, sediment stakes, and ADCP surveys). Full descriptions of these surveys are provided under separate cover. This section also summarizes the objectives and methodologies used in the sediment and tissue sample collections; detailed sample acquisition information is provided in SEA et al. (2003a). Section 2 also notes deviations from the proposed and approved portions of the Round 1/1A sampling plans that occurred during Round 1.

Section 3: Sample Analyses and Data Management. Section 3 summarizes the physical system data analysis processes. This section also provides a detailed account of the sediment and tissue sample processing and laboratory analyses, highlighting deviations from the Round 1 QAPP. The benthic infauna data evaluation process is

described. The chemical data validation and database management processes are also detailed, including the development of the Round 1 site characterization and risk assessment (SCRA) database from the main Round 1 database.

Section 4: Round 1 Results. This section summarizes the results of the physica1 system studies (bathymetric change data, sediment stake monitoring, and ADCP surveys), and presents the Round 1 sediment and tissue chemistry results.

Appendices: Appendix A is the previously submitted technical memorandum that presents the rules that were followed for the development of the Round 1 SCRA database from the Round 1 main database. Appendix B details the 2004 bathymetric change analysis that is summarized in the main report. Appendix C is the previously submitted Interim Deliverable for Human Health Risk Assessment: Round 1 Tissue Exposure Point Concentrations. Appendix D is the full SCRA database. Appendix E is a summary of the chemical data quality review and validation process. Finally, Appendix F is a crosstab file of SCRA data for the subset of indicator chemicals that are mapped in this report.

2.0 DATA COLLECTION ACTIVITIES

Round 1 data collection activities are summarized in the sections that follow. Detailed descriptions of the data collection methods associated with each type of data were included in the following documents, which were submitted to EPA under separate cover:

- Four multibeam bathymetry survey Reports (DEA 2002a; SEA 2003a; SEA and DEA 2003; Integral and DEA 2004)
- Three ADCP reports (DEA 2002b, 2003b, 2004)
- A sediment stake erosion/accretion monitoring report for July 2002 - January 2004 (Anchor 2003)
- A Round 1 field sampling report (SEA et al. 2003) that summarizes the Portland Harbor RI/FS Round 1 field sampling activities conducted from June 24 through December 20, 2002.

Figures 2-1a-b provide an overview of all station locations and sample types associated with the Round 1 fieldwork, with the exception of the bathymetry and ADCP surveys. These maps show the sediment stake locations, the beach and river surface sediment stations, the benthic infauna and multiplate stations, and the fish and invertebrate tissue sampling stations and zones.

2.1 PHYSICAL SYSTEM DATA COLLECTION

The goal of the physical system data collection activities is to obtain data on physical processes in the lower Willamette River (LWR), especially those related to sediment stability, erosion, and accretion. This information will also be used to support the hydrodynamic/sediment transport modeling being done as part of the RI/FS (West 2004). An overall understanding of physical processes in the river is needed to support the evaluation of risk (e.g., where are buried contaminated sediments likely to be re-exposed), and ultimately to develop and screen remedial alternatives.

Three physical system data types were collected or continued to be collected in Round 1:

- Four precision multibeam bathymetric surveys to document riverbed elevation changes over time (January 2002, September 2002, May 2003, February 2004).
- Time-series sediment stake measurements to document nearshore bank elevation changes (July 2002 – June 2004)
- Three ADCP surveys to provide flow measurements during specific hydrological conditions, including a high flow event in January/February 2004.

2.1.1 Bathymetry

Multibeam bathymetry surveys of the LWR from RM 0 (convergence with the Columbia River) to RM 15.6 (upstream end of Ross Island) were initiated in the winter of 2001 in accordance with the EPA-approved bathymetric survey work plan (DEA 2001). Bathymetric surveys were conducted by David Evans Associates, Inc. (DEA) in January 2002, September 2002, May 2003, and in February 2004 immediately following a relatively high-flow event (> 120,000 cfs) in the LWR. The methods used to conduct these surveys and process the data have been presented previously in the aforementioned documents provided to EPA.

2.1.2 Sediment Stakes

From July 2002 to June 2004, shoreline/beach sediment erosion/accretion rates were monitored periodically at eight facilities between river miles (RMs) 2 and 9 along the LWR. The sites included Portland General Electric (PGE), Terminal 4, Gasco, Willamette Cove, ATOFINA, GATX, Coast Guard, and Equilon (Figures 2-2a-c). No suitable location for the stakes was found at Schnitzer Steel, which was an additional proposed location. The study was initiated on July 17, 2002 and is fully described in a separate report (Anchor 2004). The PVC stakes were driven into the sediment at three different elevations along a transect perpendicular to the shoreline at each facility. Target elevations for the stake locations were the 10^{th} percentile (low stake), the 50^{th} percentile (median stake), and the 90^{th} percentile (high stake) of the river stage measured at U.S. Geological Survey gage station #14211720.

The stakes were installed so that the top of each one was approximately 30 cm above the sediment surface. Monitoring of erosion/accretion at each location consisted of periodic measurements of the distance from the top of the stake to the existing sediment surface. Measurements were recorded each month during the first five months of the study (August through December 2002), in March, July, and October 2003, and in January and June 2004 when the investigation terminated.

2.1.2 ADCP Surveys

DEA conducted three single-day ADCP surveys in the LWR. The first survey was conducted on April 19, 2002 along 16 transects from RM 1 to 11 during a high-water event. On May 13, 2003, multiple ADCP profiles were collected along three transects in the vicinity of the Multnomah Channel (MC) (RM 3). In addition, a fourth transect was located in the MC. These ADCP transects were repeated 5-6 times over a 14-hour period in order to accumulate water flow data over a complete tidal cycle. On January 31, 2004, an ADCP survey was conducted during a relatively high-flow event along 17 transects in the LWR between RM 0 and 11. Detailed ADCP survey and data processing methods are described in DEA (2002b, 2003b, 2004).

2.2 SEDIMENT AND TISSUE SAMPLE COLLECTION

Sediment (river and beach sediments) and tissue samples were collected throughout the initial study area (ISA) during Round 1 to support the evaluation of the nature and extent of contaminants at the Site and the ecological and human health risk assessments (ERA and HHRA). The Round 1 field effort focused primarily on chemical concentrations in tissue and beach sediment samples. A limited number of river surface sediment samples were collected in Round 1, and most of these were samples collocated with tissue samples to support the ERA. The major river sediment nature and extent sampling effort is now being conducted as Round 2 (2004).

Except where noted in the Round 1 Field Sampling Report (SEA et al. 2003) or as modified by subsequent correspondence between the LWG and the EPA (e.g., EPA letter dated September 20, 2002), all sample collection activities followed the procedures described in the Round 1A and Round 1 field sampling plans (FSPs) (SEA et al. 2002a,b) and the EPA-approved Fish Tissue Sampling and Fish Tissue Compositing and Shipping Standard Operating Procedures (SOPs) (SEA et al. 2002a, 2002b).

Round 1 sediment and tissue collection activities included the following tasks:

- Collection of beach sediments in human use areas
- Collection of collocated surface sediments at sculpin, crayfish, and benthic infauna stations
- Collection of nearshore and in-channel sediments to supplement the distribution of collocated sediments
- Collection of benthic infauna at a subset of surface sediment chemistry stations and tissue sampling locations
- Collection of tissue from nine fish species, one crayfish, and one clam species for chemical analysis
- Reconnaissance survey for benthic tissue and lamprey ammocoete tissue.

Figures 2-1a-b show the distribution of Round 1 sampling stations for the collection of sediment and tissue samples.

The following sections briefly describe sampling methods used for the collection of the various sample types; detailed sample collection procedures are contained in SEA et al. (2003a).

2.2.2 Sediment Sampling

River Sediments

All surface sediments were collected using either a 0.1-m^2 van Veen grab sampler or a 0.3-m^2 hydraulic power grab sampler deployed from a sampling vessel equipped with a differential GPS navigation system to target and record the coordinates at each sampling

location. A total of 26 surface sediment (0-15 cm) samples were collected at collocated tissue (sculpin, crayfish and clams) sampling locations to support the risk assessment. Surface sediments were also collected at 10 additional locations in the ISA collocated with benthic infauna collections (see Figures 2-1a-b). The collocated surface sediment samples were collected from October 16 through 25, 2002 with an additional sampling day on November 12, 2002.

Beach Sediments

To support the HHRA, composite surface beach sediment samples were collected at 20 beaches in the ISA (see Figures 2-1a-b). Beach sediment sampling occurred from October 9 through 14, 2002. Each beach was sub-divided into three transects parallel to the shoreline, as described in the FSP (SEA et al. 2002b). The river waterline was defined as the lower beach transect (transect 1). The vegetation line became the upper beach transect (transect 3), and halfway between these two transects was set as the mid-beach transect (transect 2). Field staff measured off a pre-determined, randomly-selected distance from the starting location where the first beach coordinates were recorded. A pre-determined, randomly-selected transect (1, 2, or 3) was then sampled at each pre-determined measured distance from the starting point.

Each beach was sampled using stainless-steel hand-corers at a minimum of three locations, depending on the total length of the beach. Sediment retained in the hand-corer was transferred into a foil-covered, stainless-steel bowl. Subsequent sampling of the beach proceeded in this manner until the preset number of randomly chosen locations (both along and up or down the beach) was sampled to form a composite.

2.2.2 Fish and Crayfish Sampling and Sampling Compositing

For the ecological risk and human health risk assessments, 10 fish species and one crayfish species were targeted for tissue analyses. The target species for the ERA were smallmouth bass, sculpin, subyearling chinook salmon, largescale sucker, peamouth, northern pikeminnow, Pacific lamprey ammocoetes, and crayfish. For the HHRA, the target species were carp, black crappie, bullhead, smallmouth bass, and crayfish. In addition, walleye and largescale sucker were collected as alternative species for bullhead and carp, respectively. However, they were not used for the HHRA since adequate numbers of bullhead and carp were collected.

This section briefly summarizes the fish collection methods used in Round 1. Complete field sampling details are provided in the Round 1 Field Sampling Report (SEA et al. 2003). During the collection of subyearling chinook salmon from June 24 through 27, 2002, beach seining and dip netting were the only fishing techniques used. During the collection of all remaining species from July 22 through November 10, 2002, six fishing techniques were used. These included beach seining, boat electrofishing, backpack electrofishing, trot line, angling, and crayfish traps.

In total, the LWG field teams collected fish in the ISA, both day and night, over portions of 79 days. A total of 1,870 fish were collected, including 863 sculpin, 419 crayfish, 128

largescale sucker, 90 smallmouth bass, 78 carp, 92 subyearling chinook salmon, 64 brown bullhead, 35 northern pikeminnow, 48 black crappie, 30 peamouth, 18 yellow bullhead, 3 lamprey ammocoetes, and 2 walleye.

Despite repeated backpack electrofishing and surface sediment grab sampling efforts by the LWG, EPA agency team, and tribal fisheries experts in the late summer/fall of 2002, only three lamprey ammocoetes were collected in the LWR. These efforts are detailed in SEA and Windward (2003). Due to insufficient lamprey tissue volume, no tissue chemical analyses were conducted on this species.

A field laboratory was established onsite to handle all fish collected during the Round 1 event. Fish samples were taken to the field laboratory, processed daily, and frozen. Fish specimen sample handling and processing procedures followed those detailed in EPA-approved project SOPs and the quality assurance project plan (QAPP). Fish were visually inspected and, depending on the species, filleted. Whole fish and fish fillets were individually wrapped and frozen prior to compositing. Following final agreement with EPA on the species-by-species compositing scheme, individual whole-body fish or fillets were pooled together, according to the compositing plan, in large plastic bags and labeled with the composite identification number. Frozen composite samples were then shipped frozen (on dry ice) to Axys Analytical Services Ltd. (Sidney, B.C., Canada) for tissue homogenization.

2.2.3 Macroinvertebrate Fauna and Tissue

Hester-Dendy samplers were used for quantitative sampling of the epibenthic macroinvertebrate community. These samplers are artificial substrates that are suspended above the bottom on retrievable moorings and are colonized by epibenthic macroinvertbrates. These samplers were used to characterize the composition of the epibenthic community utilizing hard-substrate habitats within the ISA. This information is being used to understand potential exposure pathways associated with riprap and other hard-bottom invertebrate communities (Integral et al. 2004)

Soft-bottom samples were collected from 22 stations in the ISA from October 22 through 25, 2002. Macroinvertebrate fauna were collected at 12 of the sculpin/crayfish collocated sediment stations and at 10 additional stations located in both nearshore areas and in the navigation channel. Surface sediment chemistry samples were also collected (see Figures 2-1a-b) at all benthic infauna stations. Most of the infauna samples were collected with a 0.1-m^2 van Veen grab sampler and sieved through a 0.5-mm sieve box. At two stations, the samples were collected by subsampling the 0.3-m^2 hydraulic power grab with 18-cm-diameter by 15-cm-length stainless steel cores. A single replicate was collected at each location to provide a qualitative indication of the macroinvertebrate assemblages in the ISA.

Prior to the infaunal community sampling, a benthic field reconnaissance was conducted in September 2002 to assess whether there was adequate benthic invertebrate tissue mass in near-surface sediments (0-15 cm depth) for chemical analysis. The results of this

reconnaissance have been detailed in SEA and Windward (2003). Because the soft-bottom benthic community is dominated by very small organisms (e.g., midges and oligochaetes), the results of the reconnaissance concluded that it would not be possible to collect adequate invertebrate biomass from the soft-bottom habitats in the LWR.

2.2.4 Clam Sampling

Based on the juvenile lamprey/benthic infauna reconnaissance survey conducted in September 2002 (SEA and Windward 2003), it was determined that the non-native bivalve species, *Corbicula fluminea*, was the largest and most widespread benthic invertebrate in the ISA and potentially in sufficient abundance to provide invertebrate tissue samples for tissue body burden analyses. In October and November 2002, clam collection was attempted by repeated casts of a 0.1-m^2 van Veen grab sampler at five target locations [see Table 3-3 in the Round 1 Field Sampling Report (SEA et al. 2003)]. In addition, an unsuccessful attempt was made to rake clams from a shallow subtidal beach at Station 07R030. Clam collection was attempted over multiple sampling days at each proposed FSP location. After considerable total effort (over 500 van Veen casts), two locations near the center of the ISA yielded more than 150 grams of tissue, which was the minimum biomass required to conduct tissue analyses for a full suite of target analytes (see Figures 2-1a-b). Fifty-three grams were collected at a third station, while the remaining two stations yielded only nominal amounts [see Table 3-3 the Round 1 Field Sampling Report (SEA et al. 2003)]. Clam sampling occurred from October 29 through November 5, 2002, with an additional day on November 12, 2002.

2.3 SAMPLING COMPLETENESS

This section summarizes the deviations from the Round 1 and 1A FSPs (SEA et al. 2002a,b) that occurred during the Round 1 field sampling due to necessary modifications to sample station locations, sampling difficulties, or the inability to obtain the proposed samples at target locations and the substitution of alternative locations.

Section 3.2.3 of this report details changes made to the approved QAPP/SOP procedures during sample processing and chemical analyses of tissue or sediment samples.

2.3.1 Station Locations

During sampling, 18 sampling stations, predominantly sculpin and crayfish, were moved relative to the original target locations proposed in the Round 1 FSP. In each case, the field crew determined that relocation was warranted because the original location proved unsuitable for sampling. Stations were typically moved following several unsuccessful attempts to collect the target organisms at a given location. Small gradients in microhabitat conditions (e.g., submerged structures or riprap), substrate type (sand vs silt), and water depth all influenced the distribution of target organisms. Table 2-1 provides a complete list of the stations and the distance and direction moved. Additional details on station location modifications are provided in the Round 1 Field Sampling Report (SEA et al. 2003).

In addition to station location, 30 new stations were incorporated into the sampling effort either at the request of EPA and its partners or because the collection of specific samples warranted a new location. These added stations included beach sediment stations, subyearling chinook salmon stations, and offshore benthic taxonomy stations. EPA and its partners requested two new stations (02R015 and 03R032, respectively) for fish tissue and collocated sediment (see Table 2-1). Four new stations were created as alternative sites for the collection of sculpin and/or crayfish tissue samples (03R034, 05R020, 06R031, 07R006) because the originally proposed sampling station locations presented unsuitable habitats for the target species. Three fishing areas for smallmouth bass (04R023, 06R024, and 08R032) were added for the HHRA and ERA. Lastly, a new clam station with collocated sediment (07R030) was added in an effort to collect adequate invertebrate tissue in this area (clams had proved difficult to obtain at Station 07R003) (see Table 2-1). However, insufficient clam tissue was collected for chemical analyses at Station 07R030, and only surface sediment chemistry data are available from that station.

2.3.2 Lamprey Ammocoetes

Lamprey ammocoetes were eliminated from the sampling program after two reconnaissance surveys determined that the apparent low abundance of the larval fish at that time of year would yield insufficient quantities for laboratory tissue analyses (SEA and Windward 2003).

2.3.3 Benthic Invertebrate Tissue

Based on the benthic reconnaissance (SEA and Windward 2003), the only benthic infauna species of sufficient abundance and size for laboratory tissue analyses was the exotic bivalve, *Corbicula fluminea*. Clams were targeted at five stations, and adequate biomass for some tissue analyses was obtained at three stations.

2.3.4 Fish and Crayfish Tissue

Table 2-2 compares all composite samples collected during Round 1 with the proposed composite samples in the Fish Tissue Sampling SOP (SEA et al. 2002a). The same number of fish and crayfish samples was collected as proposed in the SOP, with the exception of black crappie and peamouth. The number of individual fish included in some of the smallmouth bass composite samples was less than the target of five fish.

2.3.5 Benthic Infauna

One replicate sample was collected at all target stations, with the exception of Station 05R040. At that location, sorting of benthic infauna in the sample was prevented due to liquefaction of tar-like substances contained in the sampled sediments that apparently reacted with preservatives in the sample container.

3.0 SAMPLE ANALYSES AND DATA MANAGEMENT

This section describes the methods used for processing the physical system data, the sample processing and analytical laboratory methods used to analyze the sediment and tissue samples, and methods used to process benthic macroinvertebrate samples. A subsection of the chemical analyses describes deviations from the QAPP. The data management subsection explains in detail how the data validation process occurred from the lab data package to a final validated electronic data deliverable (EDD). Furthermore, it describes how the SCRA database was compiled into a series of compatible Excel tables, which were then distributed to the SCRA data users. The LDC data validation reports are provided as an attachment to Appendix E.

3.1 PHYSICAL SYSTEM

The data processing methods associated with the physical system measurements, bathymetry and ADCP surveys, and sediment stake measurements are detailed in the individual reports for each of these data types (e.g., DEA 2004, Integral and DEA 2004, Anchor 2004). The following sections summarize the data evaluation process.

3.1.1 Bathymetry

Data from each of the four bathymetric surveys (January and September 2002, May 2003, and February 2004) were plotted as contour and hillshade digital terrain maps. The survey area extended from RM 0, the convergence with the Columbia, to RM 15.6, the upper end of Ross Island. In addition to the bathymetry maps, bathymetric change maps were generated by overlaying the results of the individual surveys. These temporal overlays compare surveys 1 and 2, 2 and 3, 3 and 4, and all surveys against survey 1.

The bathymetric change maps were examined to evaluate the distribution and magnitude of riverbed elevation changes that have occurred over the period of observation. In these analyses, the surveyed area is divided into two main zones: channel and nearshore. The division between the two is delineated by the -15 foot North American Vertical Datum of 1988 (NAVD88), which corresponds approximately to the -20 foot Columbia River Datum (CRD) contour in the study area (Integral et al. 2004). The comparison of the first (T1; January 2002) and second (T2; September 2002) surveys has been presented previously in the draft Round 2A FSP (SEA et al. 2003). Comparison of the third survey (T3, May 2003) and the previous two surveys is presented in Integral et al 2004. The results of this evaluation supported the selection of a 30 cm (~ 1 ft) surface sediment sampling interval for the Round 2 river surface sediment sampling program. This Round 1 report expands this bathymetry change analysis to include the February 2004 survey, which captured the effects of a relatively high-flow event that occurred in late January/early February 2004. The results of this most recent bathymetric change data evaluation are summarized in Section 4 of this report.

3.1.2 Sediment Stake Measurements

The magnitude of erosion or accretion at the sediment stake locations was assessed by calculating the differences between the heights of each stake above the sediment surface for each monitoring event (Anchor 2003). Net erosion/accretion over the period of study was derived by comparing the subsequent measurements to the initial stake height (Anchor 2003).

3.1.3 ADCP Data Processing

DEA used WinRiver software to process the ADCP survey data. For each cross-sectional transect surveyed, plots displaying velocity magnitude (expressed in feet/second) and velocity direction (expressed as degrees from magnetic north) were created. In addition, a graph depicting the transect path with depth averaged current vectors was generated (see Section 4.1.3 for detailed explanation).

River discharge values (Q) along each transect were also calculated. Discharge is a representation of a volume of water moving past a position per unit of time (in this case expressed in units of $feet^3$/second). In order for a discharge determination to be made, the cross-sectional area of the river along an ADCP transect must be determined. DEA measured the distance from bank-to-bank along each ADCP transect in AutoCAD. Bathymetric data showing the topography of the river-bottom are available throughout the study area from the precision bathymetric survey data sets.

3.2 SEDIMENT AND TISSUE CHEMISTRY

This section provides an overview of the laboratory sample processing and analytical chemistry procedures used in Round 1. In addition, each subsection notes any deviations from the proposed Round 1/1A SOPs (SEA 2002a, SEA et al. 2002a,b) and Round 1 QAPP (SEA 2002b).

3.2.1 Sample Processing

3.2.1.1 Sediment Sample Processing Procedures

A detailed description of sediment sample handling and processing between the field collection and the analytical laboratory is included in the Round 1 Field Sampling Report (SEA et al. 2003). A brief summary is provided here.

At the end of each field day, the field crew transported all samples to the LWG field laboratory at the ATOFINA facility in Portland, OR. There, samples that could be frozen were transferred to a chest freezer. Those samples that could not be frozen (grain size, volatile organics) were held on ice for up to 4 days. The samples were then placed in coolers and driven by SEA staff to the SEA office in Olympia, WA. Upon arrival at SEA's office, the frozen sample jars were immediately transferred into a chest freezer, and the grain-size and volatile organic sample jars were transferred into refrigerators. Once all samples were checked for correct labeling and sorted by analyte groups, SEA

staff then wrapped all sample jars in bubble-wrap and placed them with either blue ice or dry ice in coolers for shipment to the analytical laboratories. The chain-of-custody was then completed at SEA's office and followed all requirements outlined in the QAPP (SEA 2002b). Samples were shipped to ARI for conventionals, metals, butyltins, PCB Aroclors, pesticides, herbicides, semivolatile organic compounds (SVOCs) and volatile organic compounds (VOCs) analyses, and to Axys for dioxins/furans and PCB congener analyses.

3.2.1.2 Tissue Sample Processing Procedures

Fish tissue sample processing, including compositing, homogenization, and shipping, followed the procedures detailed in the Fish Tissue Homogenization and Compositing SOPs (SEA 2002a, SEA et al. 2002a). Laboratory analyses followed the QAPP (SEA 2002b). A detailed description of all tissue sample handling and processing in the field and field laboratory can be found in the Round 1 Field Sampling Report (SEA et al. 2003). A brief summary is provided here.

After all fish and crayfish were measured for length and weight, and certain fish filleted. Processed samples were stored in freezers at the LWG field laboratory at ATOFINA. Once the Agency Team concurred that samples were to be combined into composites for analysis, the field laboratory personnel sorted the individual samples necessary to assemble each composite and placed the individual samples inside a resealable plastic bag, which contained a new label reflecting the composite code. Fish tissue sample composite information is presented in Figures 4-21 to 4-28.

Composites of large fish consisted of five whole fish, if a sufficient number of individual fish were collected at a given sampling location. If a fish was filleted, the scales were removed prior to filleting for fish with scales (SEA et al. 2002a). Subsequently, the skin was removed from one fillet (FS) and the other preserved with its skin (FL). Each fillet composite was composed of five fillets with skin or five skinless fillets. For crayfish and small fish, such as sculpin and subyearling chinook salmon, the composites were assembled by weight (> 150g per composite) rather than by numbers of individual samples. All fish composites were wrapped and placed into coolers with dry ice according to the protocols of the Fish Tissue Compositing and Shipping SOP (SEA et al 2002d). The chain-of-custody was then completed by a member of the field crew and followed all requirements outlined in the QAPP (SEA 2002b).

Fish without scales (i.e., brown bullhead) were to be skinned prior to filleting in accordance with the Fish Tissue Compositing and Shipping SOP (SEA et al 2002d). As stated in the Round 1 Field Sampling Report (SEA et al. 2003), prior to September 5, 2002, brown bullhead fish were skinned after filleting and only one side of this scaleless fish was skinned for the "skin off without belly flap" tissue sample (labeled as FS). Because the entire fish was not skinned prior to filleting, the fillet samples with the belly flap included (labeled as FL), which were processed prior to September 5, 2002 (5 samples in total), had the skin left on. After September 5, 2002, brown bullhead fish were processed consistent with the SOP and EPA guidance such that the entire fish was

skinned prior to filleting. The FL samples processed after September 5, 2002, were skinless, but included the belly flap, while the FS samples were skinless without the belly flap. Consequently, three tissue composites from the RM 3 to 6 fishing-zone were homogenized containing four skinless fillets and one fillet with skin each (composites: LWG01FZ0306TSBBFLC10, LWG01FZ0306TSBBFLC20, and LWG01FZ0306TSBBFLC30). Two other skinless, brown bullhead fillet composites from the RM 6 to 9 fishing-zone contained one fillet with skin each. However, the skin from these fillets was removed at Axys prior to homogenization (composites: LWG01FZ0609TSBBFLC10 and LWG01FZ0609TSBBFLC20).

Following a shipping delay by FedEx and the resultant thawing and loss of the first tissue samples sent from Axys (Sidney, B.C.) to ARI (Tukwila, WA), all subsequent fish composites samples were driven from the field laboratory at ATOFINA directly to ARI. At ARI, the chemicals of concern (COCs) were relinquished to an Axys laboratory representative, who then carried the coolers across the border into Canada. The entire trip was done in one day. Once the fish composites were homogenized, Axys retained an aliquot of that sample for dioxin/furans and PCB congeners analyses. Two separate tissue composite aliquots were then driven to Columbia Analytical Services (CAS) (Kelso, WA) for conventionals, metals, butyltins, PCB Aroclors, and pesticides analyses, and to ARI for SVOC analyses.

3.2.2 Sample Analyses

Surface sediment and tissue samples were collected and analyzed for organic, inorganic, and physical and conventional parameters according to the sample preparation and analytical procedures in the QAPP (SEA 2002b). A summary of samples collected at each station and the chemical analyses conducted for each Round 1 sample is included in Table 3-1.

3.2.2.1 Sediment Chemical Analyses

The laboratory methods of analysis for the sediment samples are included in Table 3-2. All sediment samples were analyzed for metals, organochlorine pesticides, PCB Aroclors, chlorinated herbicides, SVOCs, total organic carbon (TOC), grain size, and total solids. As required by the FSP, selected sediment samples were analyzed for PCB congeners, polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs), butyltins, and VOCs. The sediment analyses were conducted by ARI, Axys, and Rosa Environmental & Geotechnical Laboratory (REGL), Seattle, WA (subsequently acquired by ARI).

3.2.2.2 Tissue Chemical Analyses

Tissue samples were resected at the field laboratory and were composited and homogenized by Axys. The samples were analyzed for organic, inorganic, and conventional parameters according to the methods listed in Table 3-3. Axys retained an aliquot of homogenized tissue for analyses of dioxin/furans and PCB congeners on whole-body samples for HHRA species only. Aliquots of the homogenized tissue samples were sent to ARI and CAS, for chemical analysis. All tissue samples were analyzed for organochlorine pesticides, PCB Aroclors, metals, lipids, and total solids, as

specified in the FSP. Selected tissue samples were analyzed for SVOCs, PCB congeners, PCDD/Fs, and butyltins. Axys, ARI, and CAS all performed chemical analyses for the tissue samples, as indicated on Table 3-3.

3.2.3 Deviations from the QAPP

The sections below describe deviations from the QAPP (SEA 2002b) for the chemical analyses of tissue and sediment matrices.

3.2.3.1 Conventional Parameters

There were no deviations from the analytical methods listed in the QAPP for laboratory analyses conducted for conventional parameters.

3.2.3.2 Metals

The QAPP provided analytical methods for the analysis of 12 metals in sediment samples and 14 metals in tissue samples. A comparison of the methods specified in the QAPP to the methods used for metals analysis in Round 1 samples is provided in Table 3-4. With few exceptions, metals analyses in sediment and tissue samples were implemented as specified in the QAPP. The only deviations from the methods specified in the QAPP were for aluminum, manganese, and zinc, where several samples, depending on the analyte, were analyzed by inductively coupled plasma-optical emission -optical emission (ICP-OES; EPA Method 6010B) and inductively coupled plasma-mass spectrometry (ICP-MS; EPA Method 6020), and several samples were analyzed by ICP-OES, instead of ICP-MS, as specified in the QAPP. Because the aluminum, manganese, and zinc concentrations reported by ICP-OES were elevated above the laboratory method detection limits, this deviation is not significant and does not impact the usability of the affected results.

3.2.3.3 Volatile Organic Compounds

There were no deviations from the analytical methods included in the QAPP for the laboratory analysis for VOCs in sediment.

3.2.3.4 Semivolatile Organic Compounds

For selected compounds, SVOCs analysis by EPA Method 8270C full-scan and selective ion monitoring (SIM) was conducted during Round 1. The following deviations from the methods specified in the QAPP occurred for this analysis:

- The QAPP specified initial calibration of the gas chromatograph/mass spectrometer (GC/MS) with a 7-point calibration curve, of which at least one of the low standards is at the concentration of the method reporting limit (MRL). ARI analyzed the sediment and tissue samples for SVOCs and followed their internal SOP, which specified a 6-point calibration curved with a seventh point as a MRL check, instead of as a calibration standard. This deviation does not impact the quality or usability of the SVOC results.
- The QAPP required the laboratory to include all spiking compounds listed in the method in the matrix spike/matrix spike duplicate (MS/MSD) and laboratory

control sample/laboratory control sample duplicate (LCS/LCSD) samples during the SVOC analysis. ARI actually included the full list of target analytes for full-scan or SIM rather than the list of spiking compounds specified in the method. This deviation enhances the quality and usability of the results because of the additional information on the bias of the data provided from the matrix spike results.

- The QAPP allowed the laboratories to make "certain modifications to achieve the project DQOs" and indicated that any such modifications should be identified in the final report. For SVOC analysis of tissues, a silica fractionation cleanup was added to remove lipids. Because several compounds were also removed by the silica fractionation, additional SIM analyses of the un-cleaned extracts were added to the analysis scheme. This deviation enhances the quality and usability of the results.

3.2.3.5 Chlorinated Herbicides

The QAPP specified hexachloroethane and pentachlorophenol as target analytes for analysis by EPA Methods 8151A (Chlorinated Herbicides) and 8270C SIM. Because the laboratory method detection limit (MDL) study showed that hexachloroethane could not be resolved from the solvent peak, hexahloroethane was not reported by EPA Method 8151A. Hexachloroethane was reported from the 8270C SIM analysis.

Pentachlorophenol was included in the QAPP target analyte list for 8151A; however, during the laboratory's internal quality assurance review of the results conducted prior to reporting the data, the laboratory discovered that the extract cleanup used for herbicides was removing pentachlorophenol. The pentachlorophenol results were therefore flagged "NV" on the hard copy and electronic reports, indicating that the results for this compound should be reported from an alternative analysis. These deviations have no impact on the quality or usability of the results because hexachloroethane and pentachlorophenol were successfully reported by one of the alternate methods. There were no other deviations from the chlorinated herbicide analysis.

3.2.3.6 Chlorinated Pesticides and PCB Aroclors

There were no deviations for chlorinated pesticide and PCB Aroclor analyses for sediment samples. Prior to extraction of the tissue samples, CAS performed a screening level extraction and analysis to determine the appropriate mass of sample to use for extraction to ensure that the tissue sample extracts did not require excessive dilution. The screening level extraction was performed by extracting a small portion of each tissue sample in hexane and injecting an aliquot of the extract into the GC. The chromatograms were reviewed by the laboratory supervisor to determine the appropriate mass of each tissue sample for extraction. Based on the screening results, a smaller mass of tissue than required by the method and laboratory SOP was extracted for selected samples. There were no other deviations from the QAPP for pesticide or PCB Aroclor analyses.

PCBs are known to interfere in the chlorinated pesticide analysis by GC/ECD (EPA Method 8081A). In the laboratory case narratives for the Round 1 data packages, CAS

noted matrix interferences for some of the samples. When reviewing the chromatograms for the chlorinated pesticide analysis, LWG and EPA project chemists noted evidence of potential interference in the chlorinated pesticide analysis from the presence of PCBs in selected samples. EPA requested reanalysis of selected Round 1 tissue samples because of possible false positive or biased high chlorinated pesticide results due to the potential interference of PCBs in the chlorinated pesticide analysis. Additional review of the GC/ECD chromatograms for chlorinated pesticides was conducted by LWG project chemists to assess the degree of PCB interference for the chlorinated pesticide analysis.

Under LWG's direction, CAS reanalyzed selected Round 1 samples by gas chromatography/mass spectrometry (GC/MS) using a mass spectrometer equipped with an ion trap (EPA Method 8270C), which increased the sensitivity of the instrument. This methodology is not typically used for tissue analysis; however, the method was developed by CAS for the Round 1 tissue samples. Using this GC/MS ion trap method allowed separation of the chlorinated pesticide target parameters from the PCB interferences while attaining detection limits below those commonly achieved by standard GC/MS methodology. The reanalysis of the tissue samples by GC/MS ion trap was a deviation from the QAPP. This deviation enhances the quality and usability of the results because of the resolution of the PCB Aroclor interferences and confirmation of the target analytes by mass spectrometry.

3.2.3.7 PCB-Congeners

There were several deviations from the QAPP for the analysis of PCB congeners in sediment and tissue samples. The deviations are summarized below:

- The QAPP identified 13 congeners as target analytes for PCB congener analysis by EPA Method 1668A. After publication of the QAPP, but prior to the initiation of PCB congener analysis, the target analyte list for this analysis was expanded to include all 209 congeners listed in Method 1668A as target analytes in all Round 1 sediment and tissue samples.
- The CAS screening results that were generated for PCB Aroclor analysis were provided to Axys to assist them in determining the appropriate mass of sample to extract for PCB congener analysis and to create initial extraction groups. There were numerous samples for which Axys did not extract 75 grams of sample for PCB congener analysis, as specified in the QAPP, because it was determined that for many of the samples a 75-gram aliquot would result in saturation of the mass spectrometer and require excessive dilution of the sample extracts. This deviation enhanced the quality and usability of the results.
- During initial analysis of Round 1 samples, a split of the extract was generated and analyzed on a carbon column to allow for better separation of selected congeners from other congeners and interferences. The use of the carbon column is included in EPA Method 1668A; however, the use of this column was not specifically mentioned in the QAPP. This deviation enhanced the quality and usability of the results.

3.2.3.8 Dioxins and Furans

For selected tissue samples, there was insufficient sample available to extract 75 grams of tissue for dioxin and furan analysis, and therefore a smaller mass of sample was extracted for analysis. The impact on results was minimal because selected target analytes were detected in the affected samples. Additional information on the laboratory detection limits is included in Appendix E. There were no other deviations from the analytical method included in the QAPP.

3.2.3.9 Butyltins

There were no deviations from the analytical method included in the QAPP for the laboratory analysis for butyltins.

3.3 MACROINVERTEBRATE SAMPLE PROCESSING

With one exception, the laboratory methods and quality assurance procedures described in the QAPP (SEA 2002b) were followed for all macroinvertebrate sorting and taxonomic identifications on both multiplate and sediment grab samples. Due to the abundance of organisms in the samples, multiplate replicates were not sorted in their entirety but instead were sorted based on a fixed target count of macroinvertebrates to be removed from the sample (Barbour et al. 1999).

Data management of the taxonomic identifications and species enumerations provided by the contract laboratory followed the process identified in the QAPP (SEA 2002b). This ensures an easy transfer of data to EPA in the required format. Archival procedures (e.g., preservation of vials containing major taxonomic classifications or species) described in the QAPP (SEA 2002b) were also followed so that vials would not be misplaced or corrupted.

Additional details on the processing of benthic infauna samples and validation procedures, as well as the benthic data evaluation and its proposed use in the ERA, are provided in Appendix B: “Ecological Risk Assessment Approach” of the Portland Harbor RI/FS Programmatic Work Plan (Integral et al. 2004).

3.4 CHEMICAL DATA VALIDATION

As required by the QAPP, the first 5% of the data for each sample type and analytical method were submitted to EPA for data validation by EPA’s QA Office. Concurrent with EPA’s review, the data packages submitted to EPA’s QA Office for review were subjected to a full validation by the data validation subcontractor for the Round 1 data, Laboratory Data Consultants, Inc. (LDC) in Carlsbad, CA. All subsequent Round 1 data packages were subjected to Level 3 data validation.

One data package for each sample type and analytical method was submitted to LDC for full validation, as required by the QAPP. The subsequent data packages for each sample type and analytical method were subjected to Level 3 data validation, which includes the

evaluation and assessment of the sample results and applicable quality control results reported by the laboratory. The inorganic, organic, and dioxin/furan data were validated in general accordance with guidance specified by the USEPA Contract Laboratory Program National Functional Guidelines for inorganic, organic, or chlorinated dioxin/furan data review (EPA 1994, 1999, 2002), respectively. Modifications were made to the Functional Guidelines to accommodate QA/QC requirements of the non-Contract Laboratory Program (CLP) methods that were used for this project. Data qualifiers were assigned during data validation if applicable control limits were not met, in accordance with the EPA data validation guidelines (EPA 1994, 1999, 2002) and the quality control requirements included in the referenced methods. The data validation qualifiers and definitions are summarized in Table 3-5.

The following laboratory deliverables were reviewed during Level 3 and full data validation:

- The case narrative discussing analytical problems (if any) and procedures
- Chain-of-custody documentation
- Instrument calibration results
- Method blank results
- Results for laboratory quality control samples required by the referenced method, including laboratory control sample/laboratory control sample duplicate (LCS/LCSD) analyses, matrix spike/matrix spike duplicate (MS/MSD) analyses, surrogate recoveries, and other method specific quality control samples (e.g., serial dilutions for ICP analyses)
- Results for field quality control samples
- Analytical results for analyses performed.

For data packages subjected to full validation, in addition to review and assessment of the documentation identified above, the validation includes verification of reported concentrations of the results and verification of intermediate transcriptions.

After completing the data validation activities for each data package, a data quality report and a tabular summary of qualified data were generated by LDC. The LDC data quality reports are included in Attachment 1 of Appendix E. For the chlorinated pesticide data, additional data validation was conducted by LWG chemists, in response to EPA's data validation report. The data validation process and qualifiers assigned to the chlorinated pesticide data are summarized in a technical memorandum (Attachment 2 of Appendix E). The data validation qualifiers assigned during validation by LDC were added to the laboratory report forms and also added electronically to the laboratory EDD. The revised EDDs were submitted together with the hard-copy data validation reports as the project deliverable. The revised EDDs were then incorporated into the project database, as described in Section 3.4.2 below.

3.4.1 Summary of Qualified Data

Selected data not meeting the data quality criteria were qualified as undetected, estimated, tentatively identified, or rejected during validation, in accordance with the QAPP (SEA 2002b). A summary of the qualified data by parameter group, including the reasons for qualification, is included in Table 3-6. Additional information regarding the qualified data for each parameter group is included in Appendix E. Data qualified as undetected are usable for all intended purposes. Data qualified as estimated or tentatively identified are also usable for all intended purposes, with the knowledge that these data may be less precise or less accurate than unqualified data. Rejected data are not usable for any purpose.

3.4.2 Data Management

The laboratories exported sample, test, batch, and result information into comma-delimited text files with data columns arranged in an order that was recognized by the project's Environmental Quality Information System (EquIS) database. These EDDs were e-mailed to Integral (formerly SEA) where they were checked for proper EQuIS structure and appended with specific information that was unknown or hidden from the labs, such as sampling location, composite information, and field replicate and split information. If any problems were found in the structure of the EDDs, then the laboratory was notified and asked to correct the problem and resubmit the EDD. Each emailed EDD transmission, with the original, unaltered EDD attachment, was stored to document and track the laboratories' delivery of electronic data to Integral.

When the EDD structure checked out satisfactorily and the appended information was completed, the EDDs were checked electronically by loading them into the temporary section of Integral's LWG project database. In the process of loading, EQuIS checked the EDDs for correct lookup codes (such as for analytes, test methods, and sample matrices); proper relationships for results, tests, batches, and samples (to ensure all results match with a test, tests with samples, and sample/test pairs with batches); and that all derived samples (such as replicates, splits, and matrix spikes) had corresponding parent samples. In addition to these checks, EQuIS also checked "less important" characteristics, such as date and time formats and text field lengths, to ensure consistency throughout the database. Any error prevented the EDD from loading until the error was corrected. If errors were found that related to the way the lab was reporting the data or constructing the EDD, then the laboratory was notified and asked to correct the problem and resubmit the EDD. If errors were related to Excel automatically formatting date and time fields, for example, then the error was corrected and steps taken to avoid repeats of the problem (such as changing default settings in the software). Each successfully loaded EDD was stored as loaded to document and track the data that were loaded into Integral's LWG project database.

The data remained in the temporary section of the project database, where they could be queried and examined to address initial questions, until validation by LDC was complete. As LDC completed validation of the data by SDG or small groups of SDGs, the validator

qualifiers and reason codes were applied to the data in the temporary section of the database. The validated data were merged into the permanent project database in two large sets: 1) all sediment results except dioxins/furans and PCB congeners, and 2) sediment dioxins and PCB congeners and all tissue results. During the merging process, all previously performed electronic checks were repeated to ensure nothing was incorrectly modified with the application of the validation results.

Several queries were set up in the permanent database to translate the data structure to a form compatible with NOAA's Query Manager. The data translation included creating station and sample identifiers, converting the sample type code, changing the date format, and summarizing the tissue sample composite information. The translated data were imported into an Access file provided by NOAA that contained template tables for the Query Manager structure. These tables included one for stations, sediment samples, tissue samples, sediment chemistry, and tissue chemistry. A table with definitions of qualifiers and one with definitions of analytical method abbreviations were also imported.

Integral's LWG project database contains all of the data reported by the analytical laboratories. This includes field and lab replicates, lab dilutions, results for the same analyte from multiple analytical methods (SW8270 and SW8270-SIM, for example), and laboratory QA samples such as matrix spikes, surrogates, and method blanks.

The data handling rules described in *Guidelines for Data Averaging and Treatment of Non-detected values for the Round 1 Database* (Appendix A) were used to create a data set for the SCRA data users. The guidelines document details the criteria used to create the SCRA database that excludes lab QA results, contains only the most appropriate dilution result and analytical method for each analyte, and contains the average of laboratory duplicates and field splits. Excluding the lab QA results from the project database was a simple database-querying step. Selection of the most appropriate dilution was either done by the reporting laboratory or by the data validator. Selection of the most appropriate analytical method is described in the guidelines document and was accomplished by flagging the appropriate method in the project database. Appendix A describes the rules used for averaging data and carrying qualifiers. Because this was the most intensive data reduction procedure, the data were divided into subgroups, and approximately 40% of each subgroup was verified. If any problems were found with the averaging, then 100% of the subgroup was verified and problems were corrected. When completed, the SCRA database was compiled into a series of database-compatible Excel tables and distributed to the SCRA data users.

4.0 ROUND 1 RESULTS

Round 1 results for the physical system studies and the sediment and tissue chemistry analyses are presented in this section.

4.1 PHYSICAL SYSTEM

4.1.1 Bathymetric Change

An analysis of bathymetric changes observed based on differences between the T1, T2, and T3 surveys was presented in a previous document (Integral et al. 2004, SEA et al. 2003). Similar analyses comparing the T1 and T3 surveys to the T4 survey is discussed fully in Appendix B and summarized here.

Vertical Change Data: T1T4

Data from the T1T4 change analysis indicate that the channel zones show greater stability than nearshore zones; 41% of the entire channel area showed no change compared to 30% of the nearshore area. No change is defined as +/- 0.25 feet, the vertical resolution of the bathymetric surveys. The data also indicate that changes in both the channel and nearshore zones are largely on the order of 1 foot or less. The total number of cells showing changes greater than 1 foot (both shallowing and deepening) over the period of study accounts for only 7.9% of the channel and 15.4% of the nearshore zones. These data continue to support the use of the 1-foot (30-cm) surface sampling interval proposed and used in the Round 2 nature and extent river sediment sampling (Integral et al. 2004, SEA et al. 2003).

Vertical Change Data: T3T4

Despite the relatively high-flow event (>120,000 cfs) that occurred immediately preceding the T4 (February 2004) survey, overall, the bathymetry in both the channel and nearshore zones was relatively stable during this period; 80% of the entire channel area and 55 % of the nearshore area showed no change. The magnitude of changes in both the channel and nearshore zones is consistent with the overall (T1T4) and previous study intervals (T1T2, T2T3), with the majority of changes occurring on the order of 1 foot or less. Areas showing changes greater than 1 foot are less common than in the previous time intervals, accounting for only 0.9% of channel zone and 2.4% of nearshore zone during T3T4.

Patterns in the Distribution of No-Change, Shallowing, and Deepening Areas

The percentages of the area within each river mile showing no change, shallowing, and deepening over the T1T4 and T3T4 study periods were graphed for the channel and nearshore zones (Figures B1 and B2, Appendix B). Patterns exhibited by the data are discussed in the following paragraphs.

T1T4 Patterns

In the channel, deepening cells are most dominant between RMs 5-7, and 10-15.7, which is consistent with the previous classification of these segments as non-depositional or transport environments (Integral et al. 2004). No-change cells dominate RMs 3-5 and 7-9, which have been characterized as transitional and depositional zones, respectively. Shallowing cells peak in RM 2-3 and RM 9-10, which is consistent with their characterization as depositional and transitional zones; these river miles also encompass the reaches that have historically required the most frequent dredging to maintain the authorized channel depth of – 40 feet.

In the nearshore, deepening cells are the dominant type in virtually every river mile, particularly RMs 0-4, 6-10, and 12-14. The proportion of no-change cells varies from 20 to 37% across the entire study area, peaking between RM 5-6 and again between RM 14-15.7. Shallowing cells do not dominate any of the nearshore areas.

T3T4 Patterns

No-change cells clearly dominate both the channel and nearshore areas during the T3T4 time period. In the channel, there is only one segment where no-change cells do not comprise the majority of the area: RM 9-10, where shallowing occurs over nearly half the area, slightly greater than the area of no change. This reach is the upstream end of the major depositional that occurs where the river widens between RM 7 and 10. The deposition observed here from T3 to T4 likely reflects the effects of the winter 2004 high-flow event. Shallowing comprises only 23% or less in all other RM segments. Deepening does not comprise more than 21% of any channel segment during this time period.

In the nearshore zones, deepening is the second-most dominant change seen over the T3T4 time period, comprising between 13 to 36% of each river mile segment. Deepening in the nearshore peaks at RM 4-5; bathymetric change maps (Appendix B) indicate that this deepening is associated with recent dredging in Slip 3, Terminal 4 and possibly propwash in that area. Shallowing comprises only 2 to 18% of the nearshore areas over the T3T4.

Surface Layer Sample Interval Evaluation

The surface layer sample interval for the Round 2 sediment sampling effort was defined as the top 1 foot of sediment, based on the previous bathymetric change evaluations (Integral et al. 2004). Consistent with the previous data, the T1T4 bathymetric data also indicate that the majority of changes are 1 foot or less in magnitude. Areas with less than 1-foot riverbed elevation change account for approximately 92% of the total channel area and 85% of the total nearshore area over the 25-month T1T4 period; this compares with 95% of total channel area and 87% of the total nearshore area over the 16-month T1T3 period. (Appendix B). Maps of the T1T4 bathymetric change data grouped into categories of less than 1 foot of change, greater than 1 foot of shallowing, and greater than 1 foot of deepening, showing the distribution and size of these different subareas, are provided in Appendix B.

4.1.2 Sediment Stakes

The measurements recorded at the low, median, and high stakes locations (low, median, and high refer to relative stake location altitudes at a given sediment stake transect) are presented in Table 4-1 and are illustrated in Figures 4-1, 4-2, and 4-3, respectively.

Low Stakes

The range of mudline elevation changes observed at low stake locations varied from 4 cm (PGE and ATOFINA) to 20 cm (Equilon). Net change from the original mudline elevation over the study period ranged from -14 cm (Terminal 4) to +20 cm (Equilon; Table 4-1).

With the exception of the Gasco location, most low stakes locations generally underwent erosion through December 2002, roughly coinciding with increasing river discharge and flow velocities, but subsequently displayed mixed patterns (Anchor 2004). The Gasco site initially showed significant accretion by September 2002, but subsequent erosion resulted in no net accretion by March 2003. Several sites (U.S. Coast Guard, ATOFINA, Gasco, PGE, and Terminal 4) displayed accretion as river discharges began decreasing following a peak in March 2003. Equilon and GATX, however, displayed erosion following the discharge peak; this behavior is attributed to the relatively exposed nature of these locations compared to the accreting stations, which are somewhat more protected by surrounding embayments or upstream structures (Anchor 2004).

Median Stakes

Disregarding the Willamette Cove location, where the median stake could not be maintained, the range of mudline elevation changes observed at median stake locations varied from 6 cm (U.S. Coast Guard) to 39 cm (Gasco). Net change from the original mudline elevation over the study period ranged from -14 cm (GATX) to +29 cm (Gasco). The median stakes at the various locations were placed at elevations ranging from 0.86 above to 1.07 feet below the target elevation of +4.96 feet (gage datum; Anchor 2004). Consequently, the period of time each stake location was submerged (i.e., influenced by the river) varied, making comparisons of behavior among the locations and relative to river discharge problematic (Anchor 2004).

The measurement records for the median stakes become spotty following the December 2002 monitoring event as the stakes at several locations were missing at various times over the remainder of the study period. Nevertheless, the available median stake data were found to generally correspond to the expected patterns of erosion during periods of increasing flow, accretion during periods of decreasing flow, and mixed patterns during periods of transition (Anchor 2004).

High Stakes

Again disregarding the Willamette Cove location, the range of measured changes at the high stakes locations ranged from 0 cm (Terminal 4) to 19 cm (Gasco). Net change from

the original mudline elevation over the available period of record ranged from -4 cm (PGE) to +9 cm (Gasco). The degree of changes observed appeared to be related not only to the elevation of the stakes, several of which were higher or lower than the target elevation (9.99 feet, gage datum), but also to the dynamic environment (relatively high energy at exposed locations or low energy in more protected locations; Anchor 2004). Only the high stakes at the GATX, U.S. Coast Guard, and Equilon locations showed complete records through the study period. Due to the variation of high stake elevations and the lack of complete records for most locations, the high stake data are likely questionable for use in evaluating the relationship between river flow and mudline elevation, and also for comparison with the elevation changes shown by the low and median stake data and bathymetric data (Anchor 2004).

General Location Trends

The stake data show that overall, except for the Gasco location, no consistent relationship was observed between changes in mudline elevations measured at the low and median stake pairs at any of the locations. As this is observational data, the general lack of consistency between low and median stakes appears real and likely reflects the different energy/sedimentary regimes that exist between frequently submerged (low) and frequently subaerial mid-level locations. At Gasco, changes at the low and median stakes appeared notably consistent; erosion and accretion generally occurred concurrently at both stakes. Changes at the Coast Guard low and median stakes appeared to roughly mirror each other, with erosion at one generally occurring concurrently with accretion at the other, though the magnitude of the changes was small (Anchor 2004).

Comparison with Bathymetric Change Data

The T2 (September 2002), T3 (May 2003), and T4 (January 2004) bathymetric surveys were conducted within the timeframe of the July 2002 to June 2004 sediment stake monitoring. Figures 2-2a-c (from Anchor 2004) illustrate the stake monitoring locations with the available T2T3 bathymetric change data in the vicinity. A comparison of stake data to the T2T3 bathymetric change data was conducted by Anchor and is presented in Table 4-2 (from Anchor 2004). Because the stake measurements were not initiated until July 2002 and missing stakes and a lower monitoring frequency beyond the fall of 2003 resulted in a less complete data set, a comparison of the stake data set with the T2T3 bathymetric surveys seemed most appropriate.

To derive the data for this table, the bathymetric change data at the stake locations were visually examined, and the overall magnitude and trend of the data was determined within a circle of approximately 100 feet, and converted to cm for comparison to the stake data (Anchor 2004). Low and median stake entries for the table were derived using the September 2002 sediment stake measurements as the initial mudline elevations for each location and estimating mudline elevations for May 2003 based from plots of the March 2003 and July 2003 data points (Figures 4-1 and 4-2). The low and median stake data were then compared to the direction and magnitude of the bathymetric change data at each stake location (Table 4-2). The results of this comparison indicate that the two data sets generally do not agree at most locations. Both of these data sets are direct

measurements of bed elevation changes over time, and there is no reason to believe that this lack of agreement between beach and nearshore riverbed elevation changes is not real. Therefore, these data suggest that there is significant variability in relatively small-scale (0-30 cm) erosion and accretion patterns along onshore (mid-beach) - offshore (shallow subtidal) transects in the LWR. This is likely a function of the seasonal rise and fall of river water levels combined with nearshore anthropogenic factors (e.g., localized boat wakes, prop wash, etc.).

4.1.3 ADCP

The first ADCP survey was conducted during a high-water event on April 19, 2002. Current profiles were collected along 16 transects in the LWR from RM 1 to 11. The most notable result was that at the time of that survey there was a significant flow out of the LWR through the Multnomah Channel (MC). Based on these results, hydrodynamic modelers from West Consultants concluded that the MC needed to be included in the numerical model of the system and that more ADCP flow data should be collected concurrent with the next bathymetry survey, preferably over a tidal cycle, to observe the flow dynamics near the MC as a function of tide.

May 2003 Survey

As recommended by the modeling team, a second ADCP survey was conducted in the LWR during the May 2003 multibeam bathymetry data collection. On May 13, 2003, multiple ADCP profiles were collected along the three transects in the LWR in the vicinity of the MC (RM 3) that had been occupied in April 2002, and a fourth transect was located within the MC. ADCP profiles were repeated 5-6 times along each transect over a 14-hour period to capture ADCP data over a complete tidal cycle. The complete results of this effort have been documented by David Evans and Associates (DEA 2003b).

Table 4-3 shows the discharges (Q, ft^3/sec) observed along the four transects of the May 2003 survey during each ADCP pass. Positive values equal net downstream discharge in the LWR and MC. Note that discharge, Q, does not equate directly to flow velocities because the cross-sectional area of the river varies from place-to-place. Net discharge was downstream along all transects over the entire tidal cycle with two exceptions: during the maximum flood tide (Pass 5), net discharge was upstream at Transect 3 (downstream of the MC) and at Transect 4 (at the MC head). Water velocities along the LWR transects were relatively steady during Passes 1 to 3, the ebb tide. Velocities averaged from 0.25 – 0.5 ft/sec in the LWR channel. Velocities were slightly higher (0.5 – 1.0 ft/sec) in the MC. Near low tide, Pass 4, water velocities in the LWR slowed and began to reverse direction, first along the eastern bank and propagating westward. By Pass 5, the flood tide, the water flow was completely upstream at Transect 3, and reversed direction along the eastern half of the LWR at Transect 4, and along a narrow portion of the eastern bank at Transect 5. By Pass 6, the high tide, flow velocities, both in direction and magnitude, were comparable those seen during the morning ebb tide.

January 2004 Survey

A third ADCP survey was conducted on January 31, 2004 to provide data on current velocities during a high-flow event. The complete results of this effort have been documented in DEA (2004).

Seventeen transects between RMs 0 and 11 were profiled over a 9-hour period during a 130,000 cubic feet per second (130 kCFS) flood event (DEA 2004). Selected transects near the head of the MC (3, 4, 5, and 17) were run once in the morning on a rising tide, and again in the afternoon on a falling tide (DEA 2004). The discharge (Q) data from these transects are included in Table 4-3. Measured discharges just upstream of Multnomah Channel, transect 5, peaked at about 130 kCFS during this high-flow event; this is 3-4 times greater than the peak discharges measured in May 2003. Based on the measured discharges in the Multnomah, approximately 25% of the Willamette flow was exiting the system down the channel during the high-flow event. During the lower flow period in May 2003, over 50% of the Willamette flow was discharging down the Multnomah during the ebbing tide.

Plots of the winter 2004 transect data indicate that flow is predominantly downstream throughout the survey, with current speeds up to a maximum of 3.5 ft/sec observed at RM 11.0 (transect 16). Lower maximum velocities on the order of approximately 2.5 ft/sec are observed in the downstream transects, particularly downstream of the MC. Areas of relatively sluggish flow or eddies are apparent on the margins of certain transects that enter relatively shallow or protected areas (transects 3, 6, 9, 10), and across the entrance to Swan Island Lagoon. River level readings from the Morrison Street Gage at RM 12.8 at the time of the survey display a tidal signal, indicating that the tidal influence on river levels was not overridden by the high-flow event (DEA 2004).

4.2 SEDIMENT AND TISSUE CHEMISTRY

This section describes the Round 1 sediment and tissue chemistry results. Beach and river sediment data are discussed separately due to the different nature of the environments and the sampling methods.

For the purposes of this report, results are presented primarily to assess the nature and extent of contaminants in sediment and tissue within the ISA and may not be applicable to other elements of the RI/FS. When calculating summed analyte concentration values, such as total PCB Aroclors, total LPAHs, total HPAHs, and total 4,4'-DDT (i.e., 4-4'-DDT, -DDD, -DDE), a value of zero was used for non-detects on an individual sample basis. The summed LPAHs include naphthalene, 2-methyl naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene. Summed HPAHs include fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(k and b) flouranthenes, benzo(a)pyrene, indenopyrene, dibenz(a,h)anthracene, and benzo(g,h,i)perylene. 2,3,7,8-Tetrachlorodibenzo-p-dioxin TEQ values were calculated with World Health Organization 1997 TEFs for mammals (see Appendix F). Sample statistics presented in tables and text were calculated using reported detection limit values for non-detects.

4.2.1 Sediment Chemistry Results

This section describes the chemical concentrations measured in beach and riverbed sediment samples. The SCRA data for all sediment samples are provided in an Excel flat file table format in Appendix D. The SCRA data set was generated in accordance with the guidelines specified in Appendix A (see Section 3.4.2). The major analyte groups measured in river and beach sediment samples included conventionals (grain size, TOC), metals, PCB Aroclors, organochlorine pesticides, SVOCs, and herbicides. In addition, butyltins, PCB congeners, VOCs, and dioxins and furans were measured in selected river sediment samples. A complete list of all analytes measured, along with their reference analytical methods, is provided in Table A7-4 of the QAPP (SEA 2002b). Any deviations from the methods prescribed in the QAPP are discussed in Section 3.2.3.

It is important to note that the major objective of the Round 1 river sediment sampling effort was to support the ecological and human health risk assessments (e.g., sediment samples collocated with fish and shellfish tissue samples). While the Round 1 sediment data will be included with and evaluated as part of a detailed assessment of the nature and extent of chemical contaminants in sediments following the extensive Round 2 river sediment sampling program, this Round 1 site characterization summary report includes only brief descriptions of general trends in the spatial distribution of chemicals in river sediments based on the comparatively few river surface sediment samples collected in Round 1.

Figures 4-4 through 4-20 show the mapped distribution, on a chemical-by-chemical basis, of the Round 1 sediment data, including the beach and in-water river samples. The specific chemicals mapped include most of the chemicals that were frequently (greater than 10% of the surface and subsurface samples) detected in the LWR in the historic data set (Integral et al 2004). These include arsenic, cadmium, copper, lead, mercury, zinc, total PCB Aroclors, total 4,4'-DDT, dibenzofuran, 4-methyphenol, bis(2-ethylhexyl) phthalate, total LPAHs, and total HPAHs. The complete data set used to generate these maps, containing all sediment and tissue samples, is provided as an Excel crosstab table, in Appendix F. The concentration categories (e.g., breaks) used in Figures 4-4 through 4-20 are the same ones used in the Work Plan, and these were derived from the frequency distribution in the historic data set for these compounds. In addition, the Round 1 sediment concentrations of 2,3,7,8-TCDD dioxin TEQ and 4,4'-DDT, -DDD, -DDE are mapped and the percent TOC and the percent fines at each station are included on each map. Chemicals that were mapped in the Work Plan but are not mapped in this report include TBT and xylene; these compounds were only analyzed in five and one Round 1 river sediment samples, respectively.

4.2.1.1 Beach Sediments

Summary statistics for all analytes measured in the 22 Round 1 beach sediment samples are compiled in Table 4-4. Figures 4-4 through 4-20 show the mapped distribution, on a chemical-by-chemical basis, of the Round 1 beach sediment data, which are indicated by a "B" in the sample identification code (e.g., 03B031). Graphs showing the frequency distributions of the beach and river sediment data combined (all Round 1 data) for each

analyte are included as inserts on the maps to illustrate the overall range of measured concentrations.

As shown in Table 4-4, all metals except for selenium were detected, and most metals were detected in all 22 beach samples.

Three PCB Aroclors (1248, 1254 and 1260) were detected in the beach samples and detected concentrations of total PCBs, based on Aroclors, ranged from 2.5 to 80 µg/kg, with an overall mean value of 15.9 µg/kg. With the exception of chlordane and 4,4'-DDT, -DDD, -DDE, and their isomers, no organochlorine pesticides were detected. Detected concentrations of total 4,4'-DDT (sum of 4,4'-DDT and its metabolites (i.e., 4,4'-DDD, -DDE) ranged from 0.38 to 212 µg/kg, with an overall mean of 15.3 µg/kg.

Of the SVOCs analyzed, carbazole, dibenzofuran, hexachlorobenzene, pentachlorophenol, diethyl phthalate, dibutyl phthalate, bis(2-ethylhexyl) phthalate, 7 LPAHs and 10 HPAHs were detected in the beach samples. Herbicides were not detected in any of the beach samples.

4.2.1.2 River Sediments

Summary statistics for all analytes measured in river sediment samples are shown in Table 4-5. Figures 4-4 through 4-20 show the distribution, on a chemical-by-chemical basis, of the Round 1 sediment data, including all 46 river-bed samples, which are indicated by an "R" in the sample identification code (e.g., 03R001), as well as collocated fish (sculpin) and shellfish (crayfish) tissue samples. Graphs showing the frequency distributions of the sediment data for each analyte for all Round 1 samples (beach and river sediments) are included as inserts on the maps to illustrate the overall range of measured concentrations.

As shown in Table 4-5, aluminum, antimony, arsenic, cadmium, chromium, copper, nickel, and zinc were detected in 100% of the 46 river samples collected in Round 1, while lead was detected in 45 of 46 samples, silver in 30 samples, and mercury and antimony in 18 and 14 samples, respectively. Selenium was detected at only one location. Bulk organotins were detected at all three locations (5 total samples) where they were analyzed, with the exception of tetrabutyltin, which was not detected in any of the samples. Detected tributyltin ion concentrations ranged from 14.2 to 57 µg/kg, with an overall mean concentration of 32 µg/kg.

PCB Aroclors 1242 [7% frequency of detection (FOD)], 1248 (13% FOD), 1254 (44% FOD), and 1260 (41% FOD) were detected in one or more of the sediment samples. Total PCB Aroclors were detected in 67% of the samples, and detected total PCB Aroclor concentrations ranged from 6.6 to 1,500 µg/kg, with a mean value of 239 µg/kg. The pesticides mirex (7% FOD), beta-endosulfan (7% FOD), gamma-hexachlorocyclohexane (4% FOD), and all three isomers of 4,4' DDT, 4,4'-DDD, and 4,4'-DDE were the only pesticides detected in the river sediment samples. Total 4,4'-DDT (sum of 4,4'-DDT and its metabolites) was detected in 50% of the samples tested and ranged in concentration from 0.82 to 10,600 µg/kg, with an overall mean value of 252 µg/kg. The maximum

detected concentrations of mirex, beta-endosulfan, and gamma-hexachlorocyclohexane were 130 µg/kg, 130 µg/kg, and 430 µg/kg, respectively.

Of the SVOCs that were analyzed, carbazole (mean 248 µg/kg) was detected most frequently in 91% of the samples, followed by dibenzofuran (mean 117 µg/kg) in 72% of the samples, and bis(2-ethylhexyl)phthalate (mean 1,180 µg/kg) in 72% of the samples. All other detected SVOCs (excluding PAHs) were detected in less than 50% of the samples. PAHs were detected in all 46 samples. Total LPAH-detected concentrations ranged from 29 to 117,000 µg/kg, with a mean value of 5,360 µg/kg. Total HPAH-detected concentrations ranged from 67.7 to 343,000 µg/kg, with a mean value of 21,600 µg/kg.

The only VOC detected was acetone in a single sample (13 µg/kg); acetone is a common laboratory contaminant.

As with the beach sediment samples, no herbicides were detected in the river sediment samples.

Dioxins and furans and PCB congeners were detected in all of the 11 river sediment samples where they were analyzed. Most of the individual dioxin and furan congeners were detected in the 11 samples tested. The calculated 2,3,7,8-TCDD TEQ values ranged from 2.05 to 16,600 pg/g, with an overall mean of 1,540 pg/g.

4.2.2 Tissue Chemistry Results

This section briefly describes the results for chemical concentrations in tissue samples of the various sampled species. The SCRA data for all tissue samples is provided in Appendix F. The SCRA data were reduced according to guidelines specified in Appendix A (see Section 3.4.2). Round 1 tissue exposure point concentrations for the HHRA are provided in Appendix C. Field replicate samples were generated for tissue samples by collecting additional fish in the field and generating two or three composite samples for each replicate station. The composite samples were generated by homogenizing up to five individual fish (or about 350 grams for crayfish and sculpin samples) for each composite sample. Because the field replicate samples for tissue were generated by compositing separate individual fish, the fish field replicate samples were treated as separate samples.

All tissue analytes are listed in Tables A7-5 of the QAPP (SEA 2002b). Any deviations from the QAPP are addressed in Section 3.2.3. In addition to whole-body tissue, fillet tissue samples were also analyzed for the HHRA fish species. Fillets with skin containing the belly flap were analyzed for all analytes except mercury and PCB, dioxin, and furan congeners. Fillets without skin were analyzed for mercury only. Note that whole-body composites contained guts that may have included prey and/or sediment. In this report, PCB congeners were labeled with their IUPAC (International Union of Pure and Applied Chemistry) PCB number for ease of reading.

During data review, a question about the identification of individual Aroclors in sediment and tissue samples arose. Aroclors 1242, 1248, 1254, and 1260 were reported for Round 1 sediment samples, while only Aroclors 1248 and 1260 were reported for Round 1 tissue samples. Review of chromatograms for a subset of the sediment and tissue samples was conducted to evaluate the PCB Aroclor identifications performed by the analytical laboratories. The difference in identification of PCB Aroclors in fish tissue and sediment samples appears to be an artifact of the method used to identify the Aroclors in fish tissue samples (see Appendix E). Differential rates of weathering and metabolism of PCB congeners change the composition and obscure the chromatographic patterns of the Aroclors. The assignment of Aroclor identifications to the fish tissue samples may not reflect the Aroclors from which the individual PCB congeners originated because of the considerable spectral overlap between the Aroclors and the effects of weathering and metabolism on the Aroclors.

4.2.1.3 Brown Bullhead

Table 4-6 provides summary statistics of chemical concentrations in Round 1 brown bullhead tissue samples. Figure 4-21a-b presents concentrations for the selected indicator chemicals and sample data for Round 1 brown bullhead tissue samples.

The mean lipids content of brown bullhead whole-body composites was 2.43%, while the fillet composites had a mean lipids content of 1.08%.

All metals, except for antimony, lead, selenium, and silver, were detected in both whole-body and fillet brown bullhead composites. Metals concentrations were consistently higher in the whole-body composites than in fillet composites, with the exception of mercury. The mean mercury concentration in skinless fillet composites was 0.0608 mg/kg, while the whole-body composites had a mean of 0.0367 mg/kg.

Total PCB Aroclor detected concentrations ranged from 67 to 1,700 µg/kg [404 µg/kg overall mean (including non-detects)] in whole-body samples and from 37 to 1,300 µg/kg (overall mean 354 µg/kg) in fillet samples. The overall mean concentrations of total 4,4'-DDT and its metabolites were 76 µg/kg in whole-body composite samples and 18.8 µg/kg in fillet composite samples. Seven other pesticides were detected in either or both composite types, with overall mean concentrations in the range of 1.1 to 25 ug/kg.

Of all PAHs analyzed, only fluoranthene (40 µg/kg for whole-body and 110 µg/kg for fillet) and phenanthrene (60 µg/kg for whole-body and 125 µg/kg for fillet) were detected in brown bullhead. Bis(2-ethylhexyl)phthalate was the only other SVOC detected (2,700 µg/kg for whole-body and 100 µg/kg for fillet).

PCB congeners and dioxins and furans were analyzed in whole-body brown bullhead composites only. Of the 209 PCB congeners analyzed, virtually all were detected. Dioxin and furan congeners were detected in all of the whole-body tissue composites. The 2,3,7,8-TCDD TEQ values ranged from 3.65 to 18.9 pg/g, with an overall mean of 8.57 pg/g.

4.2.1.4 Black Crappie

Table 4-7 provides summary statistics of chemical concentrations in Round 1 black crappie tissue samples. Figure 4-22a-b presents concentrations for the selected indicator chemicals and sample data for Round 1 black crappie tissue samples.

Black crappie whole-body composites had a mean lipids content of 5.26%, while the fillet composites had a mean of 1.4%.

Metals were detected in both whole-body and fillet black crappie composites, with the exception of antimony, chromium, lead, selenium and silver. Metals concentrations were consistently higher in whole-body than in fillet tissue, with the exception of mercury. The mean mercury concentration in skinless fillet tissue was 0.086 mg/kg, while the whole-body composites had a mean of 0.0394 mg/kg.

Total PCB Aroclor detected concentrations ranged from 85 to 250 µg/kg (mean 134 µg/kg) in whole-body samples and from 19.6 to 32 µg/kg (mean 24.1 µg/kg) in fillet samples. The mean concentration of total 4,4'-DDT and its metabolites was 76.1 µg/kg in whole-body composites and 10.8 µg/kg in fillet composite samples. Nine other pesticides were found in either or both sample types, with mean concentrations ranging from 1.1 to 3.35 ug/kg.

Black crappie samples were not analyzed for SVOCs; however, certain SVOCs were reported in the pesticides analysis. Only hexachlorobenzene (6.9 µg/kg for whole-body) and hexachlorobutadiene (1.67 µg/kg for whole-body) were detected.

PCB congeners and dioxins and furans were analyzed in black crappie whole-body composites only. Of the 209 PCB congeners analyzed, 70% were detected. Dioxin and furan congeners were detected in all of the whole-body tissue composites. 2,3,7,8-TCDD TEQ values ranged from 3.86 to 6.52 pg/g, with an overall mean of 4.61 pg/g.

4.2.1.5 Carp

Table 4-8 provides summary statistics of chemical concentrations in Round 1 carp tissue samples. Figure 4-23 presents concentrations for the selected indicator chemicals and sample data for Round 1 carp tissue samples.

The mean lipids content of carp whole-body composites was 7.88%, while the fillet composites had a mean lipids content of 4.63%.

All metals except antimony and selenium were detected in both whole-body and fillet composites. Metals concentrations were consistently higher in the whole-body composites than in fillet composites, with the exception of mercury. The mean mercury concentration in skinless fillet composites was 0.127 mg/kg, while whole-body composites had a mean of 0.041 mg/kg.

Total PCB Aroclor detected concentrations ranged from 230 to 6,500 µg/kg (mean 1,640 µg/kg) in carp whole-body samples and from 350 to 1,200 µg/kg (mean 812 µg/kg) in

fillet samples. The mean concentration of total 4,4'-DDT and its metabolites was 186 µg/kg in carp whole-body composites and 139 µg/kg in fillet composite samples. Five other pesticides were detected in carp tissue samples, with mean concentrations ranging from 1.1 to 10 ug/kg.

Carp fillet samples were not analyzed for SVOCs; however, certain SVOCs were reported in the pesticides analysis. Hexachlorobenzene was the only SVOC detected in fillet tissue composites. In whole-body samples, 2-methylhaphthalene, acenaphthene, fluorene, and naphthalene were the only SVOCs detected, with total LPAH detected concentrations ranging from 111 to 222 µg/kg (mean 167 µg/kg).

PCB congeners and dioxins and furans were analyzed in carp whole-body composites only. Of the 209 PCB congeners analyzed, 72% were detected. Dioxin and furan congeners were detected in all of the whole-body tissue composites. 2,3,7,8-TCDD TEQ values ranged from 7.94 to 49.9 pg/g, with an overall mean of 18.0 pg/g.

4.2.1.6 Clam

Table 4-9 provides summary statistics of chemical concentrations in Round 1 clam tissue samples. Figure 4-24 presents selected chemical concentrations and sample data for Round 1 clam tissue samples.

Lipid concentrations in clam whole-body composites ranged from 0.837 to 1.7%, with a mean of 1.18%.

All metals except selenium were detected. The mean mercury concentration in the clam whole-body composites was 0.00967 mg/kg. All butyltins except for tetrabutyltin were detected. Tributyltin concentrations ranged from 4.4 to 7.6 µg/kg, with a mean of 6.0 µg/kg.

Total PCB Aroclor detected concentrations ranged from 62 to 120 µg/kg, with a mean of 86.3 µg/kg. Detected concentrations of total 4,4'-DDT and its metabolites in whole-body composites ranged from 9.7 to 330 µg/kg, with a mean of 148 µg/kg. Six other pesticides were detected in clam tissue, with mean concentrations in the range of 0.39 to 2.7 ug/kg.

Of all SVOCs analyzed, only benyl alcohol (mean 1,300 µg/kg), phenol (mean 2,600 µg/kg), and four HPAHs were detected in whole-body composites. No phthalates or LPAHs were detected. The only HPAHs detected were benz(a)anthracene (mean 50 µg/kg), chrysene (mean 53 µg/kg), fluoranthene (mean 59.3 µg/kg) and pyrene (mean 71 µg/kg).

Clam samples were not analyzed for PCB congeners and dioxins and furans.

4.2.1.7 Crayfish

Table 4-10 provides summary statistics of chemical concentrations in Round 1 crayfish tissue samples. Figures 4-4 through 4-20 present concentrations for selected indicator chemicals for Round 1 crayfish tissue and collocated sediment samples.

Lipid concentrations in crayfish whole-body composites ranged from 0.16 to 1.3% and a mean of 0.781%.

All metals except for selenium were detected. The mean mercury concentration was 0.0283 mg/kg.

Total PCB Aroclor detected concentrations ranged from 16 to 280 µg/kg, with an overall mean of 30.7 µg/kg; only Aroclor 1260 was detected. All of the DDT isomers, and trans-chlordane, beta-endosulfan, and endrin were detected in one or more of the crayfish samples. The detected concentrations of total 4,4'-DDT and its metabolites in whole-body composites ranged from 1.6 to 78 µg/kg, with an overall mean of 9.15 µg/kg. The overall mean concentrations of the other three pesticides that were detected ranged from 1.15 to 1.34 ug/kg.

With the exception of PAHs, the only SVOCs detected in whole-body composites were 4-methylphenol (mean 112 µg/kg), pentachlorophenol (mean 130 µg/kg), and phenol (mean 520 µg/kg). Phenanthrene, benz(a)anthracene, chrysene, fluoranthene, and pyrene were the only PAHs detected. The only detected concentration of total LPAHs was 97 µg/kg. Total HPAH-detected concentrations ranged from 93 to 380 µg/kg, with an overall mean of 68 µg/kg.

Dioxin and furan congeners were detected in all of the whole-body tissue composites. 2,3,7,8-TCDD TEQ values ranged from 1.84 to 23.8 pg/g, with an overall mean of 5.0 pg/g.

4.2.1.8 Largescale Sucker

Table 4-11 provides summary statistics of chemical concentrations in Round 1 largescale sucker tissue samples. Figure 4-25a-b presents selected chemical concentrations and sample data for Round 1 largescale sucker tissue samples.

Lipid concentrations in largescale sucker whole-body composites ranged from 5.4 to 8.7% and a mean of 7.56%.

All metals except for selenium and silver were detected. The mean mercury concentration was 0.0677 mg/kg.

Total PCB Aroclor detected concentrations ranged from 95 to 2,020 µg/kg, with an overall mean of 819 µg/kg. Detected concentrations of total 4,4'-DDT and its metabolites in whole-body composites ranged from 126 to 580 µg/kg, with an overall mean of 235 µg/kg. Four additional pesticides were detected in one or more samples, with mean concentrations in the range of 2.3 to 11 ug/kg.

The SVOC, bis(2-ethylhexyl) phthalate, was detected at concentrations ranging from 800 to 3,000 µg/kg (overall mean 692 µg/kg). Total detected LPAHs ranged from 42 to 147 µg/kg, with an overall mean of 50.7 µg/kg. No HPAHs were detected.

Largescale sucker samples were not analyzed for PCB congeners and dioxins and furans.

4.2.1.9 Northern Pikeminnow

Table 4-12 provides summary statistics of chemical concentrations in Round 1 northern pikeminnow tissue samples. Figure 4-26a-b presents selected chemical concentrations and sample data for Round 1 northern pikeminnow tissue samples.

Lipid concentrations in northern pikeminnow whole-body composites ranged from 2.3 to 8.1% and a mean of 5.25%.

All metals except for antimony and silver were detected. The mean mercury concentration was 0.28 mg/kg.

Total PCB Aroclor detected concentrations ranged from 370 to 1,800 µg/kg, with an overall mean of 833 µg/kg. Detected concentrations of total 4,4'-DDT and its metabolites in whole-body composites ranged from 145 to 588 µg/kg, with an overall mean of 293 µg/kg. Methoxychlor (17 µg/kg) was the only other pesticide detected in the samples.

The northern pikeminnow whole-body composite samples were not analyzed for SVOCs, PCB congeners, or dioxins and furans.

4.2.1.10 Peamouth

Table 4-13 provides summary statistics of chemical concentrations in Round 1 peamouth tissue samples. Figure 4-26a-b presents selected chemical concentrations and sample data for Round 1 peamouth tissue samples.

Lipid concentrations in peamouth whole-body composites ranged from 6.93% to 10.7 % and a mean of 8.93%.

All metals except for antimony and silver were detected. The mean mercury concentration was 0.0383 mg/kg.

Total PCB Aroclor detected concentrations ranged from 138 to 290 µg/kg, with an overall mean of 187 µg/kg. Detected concentrations of total 4,4'-DDT and its metabolites in whole-body composites ranged from 127 to 215 µg/kg, with an overall mean of 159 µg/kg. One other pesticide, cis-chlordane, was detected (overall mean 2.65 ug/kg).

The peamouth whole-body composite samples were not analyzed for SVOCs; however, certain SVOCs were reported in the pesticides analysis. Hexachlorobenzene (overall mean 5.63 µg/kg) and hexachloroethane (mean 2.08 µg/kg) were the only SVOCs detected.

Peamouth samples were not analyzed for PCB congeners and dioxins and furans.

4.2.1.11 Sculpin

Table 4-14 provides summary statistics of chemical concentrations in Round 1 sculpin tissue samples. Figures 4-4 through 4-20 present selected chemical concentrations data for Round 1 sculpin tissue and collocated sediment samples.

Lipid concentrations in sculpin whole-body composites ranged from 2.2 to 6.0% and a mean of 4.17%.

All metals except for antimony were detected in sculpin. The mean mercury concentration was 0.0416 mg/kg.

Total PCB Aroclor-detected concentrations ranged from 62 to 3,360 µg/kg, with an overall mean of 562 µg/kg. Detected concentrations of total 4,4'-DDT and its metabolites in sculpin whole-body composites ranged from 16 to 2,640 µg/kg, with an overall mean of 181 µg/kg. Ten other pesticides were detected, with overall mean concentrations in the range of 2.52 to 8.53 ug/kg.

Dibenzofuran (overall mean 30.6 µg/kg) and hexachlorobutadiene (overall mean 4.95 µg/kg) were detected in the sculpin whole-body composites. Of the phenols and phthalates analyzed, 4-methylphenol (overall mean 31.6 µg/kg), bis(2-ethylhexyl) phthalate (overall mean 1,620 µg/kg), and di-n-octyl phthalate (overall mean 319 µg/kg) were detected. Three LPAHs were detected in one or more of the whole-body composite samples (acenaphthene, fluorene, naphthalene). Total LPAHs ranged from 29 to 132 µg/kg, with an overall mean of 40.3 µg/kg. No HPAHs were detected.

Dioxin and furan congeners were detected in all of the sculpin whole-body tissue composites. 2,3,7,8-TCDD TEQ values ranged from 7.03 to 54.1 pg/g, with an overall mean of 21.2 pg/g.

4.2.1.12 Smallmouth Bass

Table 4-15 provides summary statistics of chemical concentrations in Round 1 smallmouth bass tissue samples. Figure 4-28a-b presents concentrations for selected indicator chemicals and sample data for Round 1 smallmouth bass tissue samples.

The mean lipids content of smallmouth bass whole-body composites was 5.44%, while the fillet composites had a mean lipids content of 0.818%.

All metals, except for silver, antimony, chromium and selenium, were detected in both whole-body and fillet smallmouth bass composites. Metals concentrations were consistently higher in whole-body than in fillet composites, with the exception of mercury. The mean mercury concentration in skinless fillet composites was 0.0946 mg/kg, while whole-body composites had a mean of 0.0831 mg/kg.

Total PCB Aroclor detected concentrations ranged from 90 to 4,500 µg/kg (mean 1,110 µg/kg) in whole-body samples and from 39 to 93 µg/kg (mean 62 µg/kg) in fillet samples. The mean concentration of total 4,4'-DDT and its metabolites was 198 µg/kg in

smallmouth bass whole-body composites and 26.9 µg/kg in the fillet composite samples. Seven other pesticides were detected in either or both composite types, with overall mean concentrations within the range of 1.3 to 12.2 ug/kg.

Smallmouth bass fillet samples were not analyzed for SVOCs; however, certain SVOCs were reported in the pesticides analysis. No SVOCs were detected in fillet samples. With the exception of PAHs, dibenzofuran (overall mean 33.6 µg/kg), bis(2-ethylhexyl) phthalate (overall mean 8,750 µg/kg) and di-n-octyl phthalate (overall mean 504 µg/kg) were the only SVOCs detected in whole-body composites. 2-Methylnaphthalene, acenaphthene, fluorene, naphthalene, phenanthrene fluoranthene, and pyrene were the only PAHs detected. Total detected LPAHs concentrations ranged from 31 to 308 µg/kg, with an overall mean of 75.7 µg/kg. HPAHs were detected in one composite at a total HPAH concentration of 75 µg/kg.

PCB congeners and dioxins and furans were analyzed in the smallmouth bass whole-body composites only. Dioxin and furan congeners were detected in all of the whole-body tissue composites. 2,3,7,8-TCDD TEQ values ranged from 9.37 to 38.1 pg/g, with a mean of 19.7 pg/g.

4.2.1.13 Sub-yearling Chinook Salmon

Table 4-16 provides summary statistics of chemical concentrations in Round 1 sub-yearling chinook salmon whole-body tissue samples. Figure 4-29 presents selected chemical concentrations and sample data for Round 1 sub-yearling chinook salmon tissue samples.

Lipid concentrations in sub-yearling chinook salmon whole-body composites ranged from 2.2 to 3.6% and a mean of 2.9%.

All metals, except for antimony, selenium and silver, were detected in the sub-yearling chinook samples. The mean mercury concentration was 0.0178 mg/kg.

Total PCB Aroclor detected concentrations ranged from 30 to 100 µg/kg, with an overall mean of 55.8 µg/kg. Detected concentrations of total 4,4'-DDT and its metabolites in whole-body composites ranged from 24.2 to 39.5 µg/kg, with an overall mean of 31.2 µg/kg. Five other pesticides were detected with overall mean concentrations in the range of 1.17 to 8.12 ug/kg.

Of all the SVOCs analyzed in whole-body sub-yearling chinook composites, only naphthalene (33 µg/kg) was detected in a single composite (16.7% of the samples).

The sub-yearling chinook salmon samples were not analyzed for PCB congeners or dioxins and furans.

4.2.3 Tissue and Sediment Concentration Distributions

The distributions of contaminants in Round 1 fish and shellfish tissue samples, both between species and spatially within the ISA, are described in this section. The spatial

distribution of chemicals in sediment is not discussed here because, as planned, relatively few sediment samples were collected in Round 1, and the sample coverage does not facilitate a useful discussion of contaminant distribution within the ISA. Over 1,000 sediment samples are being collected during Round 2 of the RI/FS. A comprehensive assessment of the distribution of contaminants in sediment will be provided at the conclusion of Round 2 in the Comprehensive Round 2 Site Characterization Summary Report.

4.2.3.1 Collocated Sediment and Tissue

Figures 4-4 through 4-20 present the concentrations of selected indicator chemicals for all collocated Round 1 sediment, sculpin, and crayfish tissue samples. These data are mapped to illustrate the spatial distribution of the data. Frequency distributions showing the relative distributions of the sediment concentrations (dry weight) and sculpin and crayfish tissue concentrations (wet weight) for each compound are included on each map. Appendix F is a tabular compilation of the data included in Figures 4-4 through 4-20. The collocated tissue and sediment data will be fully evaluated and discussed as part of the ecological risk assessment process for the Site in the Preliminary Risk Evaluation Report (Windward, in prep).

4.2.3.2 Comparison of Tissue Concentrations by Species

Table 4-17 provides summary statistics by species for Round 1 whole-body tissue composites and selected indicator chemicals. Table 4-18 provides similar information for the Round 1 fillet tissue composites.

Whole-Body Tissue Concentrations

Most metals were detected at very high FODs (i.e., greater than 90%) in most species. The highest detected and mean concentrations of arsenic were in clams. Cadmium concentrations were highest in carp and clams. Crayfish and clams had the highest concentrations of copper. Lead had the highest detected and mean concentrations in peamouth, followed by those in carp, clams, crayfish, and sculpin. Mercury concentrations were highest in northern pikeminnow, followed by smallmouth bass. Nickel concentrations were highest in carp, followed by largescale sucker. Carp had the highest concentrations of zinc.

The distribution of organic compounds by species is more variable than that for metals. Detailed evaluation and discussion of the contaminant concentrations by species will be provided in the Preliminary Risk Evaluation Report (Windward, in prep). Bis(2-ethylhexyl)phthalate had a zero or low FOD (i.e., 33% or less) for all species in which it was analyzed; this analyte was not detected in carp, clams, crayfish, or juvenile chinook salmon. The highest detected and mean concentrations of bis(2-ethylhexyl)phthalate were in smallmouth bass and sculpin. Total HPAHs had a zero or very low FOD (i.e., 17% or less) for the fish species in which they were analyzed but were detected in 100% of the clam and 96% of the crayfish whole-body tissue samples, which also had the highest concentrations of HPAHs. Total HPAHs were not detected in carp, juvenile chinook salmon, largescale sucker, and sculpin. Total LPAHs were detected in all of the

species analyzed for LPAHs, except clams. The highest FODs for LPAHs occurred in crayfish and carp. Smallmouth bass and carp had the highest detected and mean concentrations of total LPAHs.

Total PCB Aroclors were detected in 100% of the whole-body tissue samples for all species with the exception of crayfish, which had a FOD of 44%. The highest detected and mean concentrations of total PCB Aroclors were in carp, smallmouth bass, sculpin, largescale sucker, and northern pikeminnow. Crayfish, juvenile chinook salmon, and clams had the lowest concentrations of total PCB Aroclors. Dioxins and furans were detected all the samples in which they were analyzed; the highest 2,3,7,8 TCDD TEQ values were in sculpin, smallmouth bass, and carp, while the lowest values were in black crappie. 4,4'-DDT or one of its metabolites was detected in 100% of the tissue samples. The maximum total 4,4'-DDT concentration was in sculpin; the highest mean values for total 4,4'-DDT were in northern pikeminnow, largescale sucker, smallmouth bass, carp, and sculpin. The lowest mean values for total 4,4'-DDT were in crayfish and juvenile chinook salmon. Both dibenzofuran and 4-methylphenol had zero or low FODs for all species.

Fillet Tissue Concentrations

Fillet tissue samples were analyzed for fewer species than whole-body samples. Fillet tissue chemistry results are available for black crappie, brown bullhead, carp, and smallmouth bass. With the exception of lead, all metals were detected in all species. The highest concentrations of arsenic, copper, and nickel were in smallmouth bass. The highest concentrations of cadmium, lead, mercury, and zinc were in carp. SVOCs, including PAHs, were only analyzed in brown bullhead fillet samples. Total PCB Aroclors were detected in 100% of the tissue samples, with the highest detected and mean total PCB Aroclors concentrations in brown bullhead and carp, respectively. 4,4'-DDT or one of its metabolites was detected in 100% of the tissue samples. Total 4,4'-DDT concentrations were highest in carp.

4.2.3.3 Spatial Distribution of Tissue Concentrations

The spatial distributions of selected indicator chemicals in crayfish, sculpin, and smallmouth bass are described in this section. Individual fish collected from locations spanning up to 3 river miles were composited in the brown bullhead, black crappie, and carp tissue samples, so it is not constructive to evaluate spatial distributions for these species. The number of samples collected for the other fish and shellfish species does not facilitate a comprehensive discussion of the spatial distribution of their analytes. However, Figures 4-21 through 4-29 present the analytical results for the selected indicator chemicals and the locations for all of the Round 1 tissue samples.

Figure 4-30 presents concentrations by river mile of selected indicator chemicals for the 27 crayfish and 26 sculpin whole-body tissue composite samples. Where notable, apparent trends in the spatial distribution of these crayfish and sculpin tissue concentrations are discussed below.

Relatively elevated lead concentrations (i.e., elevated relative to the other Round 1 crayfish and sculpin tissue samples) in both crayfish and sculpin tissue occurred at Station 04R002 at RM 4.6 and, to a lesser degree, in sculpin at Station 07R006 at RM 7.5. In sculpin, bis(2-ethylhexyl)phthalate concentrations were generally not detected, except for peaks at two relatively distant locations within the ISA: Stations 08R003 (RM 8.2) and 04R004 (RM 4.7). Total HPAH concentrations in crayfish were highest at Station 06R004 (RM 6.8). Total LPAH concentrations in crayfish were not detected except at Station 06R004 (RM 6.8). Similarly, total LPAH concentrations in sculpin were frequently not detected or were relatively low, except at Station 06R004 (RM 6.8). The maximum detected total PCB Aroclor concentration in crayfish tissue occurred at Station 03R005 (RM 3.7). Total PCB Aroclor concentrations in sculpin tissue were quite variable; peak concentrations occurred at Stations 06R002 (RM 6.7), 02R001 (RM 2.4), and 02R015 (RM 2.3). A clear concentration in 2,3,7,8-TCDD TEQ values in crayfish tissue occurred at Station 07R006 (RM 7.3). In sculpin, the maximum 2,3,7,8-TCDD TEQ values occurred at Stations 07R006 (RM 7.3) and 02R001 (RM 2.4). The maximum total DDT concentration in crayfish was at Station 07R006 (RM 7.3). Total DDT concentrations in sculpin peaked at Stations 07R006 (RM 7.3), 07R003 (RM 7.5), 06R004 (RM 6.8), and 03R005 (RM 3.7).

Figure 4-31 presents box plots of selected indicator chemical concentrations for the 14 smallmouth bass whole-body tissue composite samples by river mile locations. Where notable, apparent trends in the spatial distribution of smallmouth bass whole-body tissue concentrations are discussed below. It is important to note that replicate composite samples were collected at three locations, while a single composite sample was collected at other locations. Furthermore, composite samples at locations 06R024 and 09R006 contained only 1 and 2 individual fish, respectively, so some of the apparent trends may be artifacts of the sample collection and compositing.

The cadmium concentration in smallmouth bass whole-body tissue was elevated at location 06R024 (RM 5.5-6.5) relative to the other sample locations. The highest concentration of copper in smallmouth bass was at 09R006 (RM 8.5-9.5). Bis(2-ethylhexyl)phthalate and total HPAHs were either undetected or detected at concentrations near their detection limits in all of the samples except for 04R023 (RM 3.5-4.5), where they were detected at relatively higher concentrations in at least one of the replicate samples. Similarly, total LPAHs were either undetected or detected at concentrations near the detection limits of its constituent compounds in all of the samples except for 07R009 (RM 6.5-7.5), where it was detected at relatively higher concentrations. The highest concentrations of total PCB Aroclors detected in smallmouth bass whole-body tissue samples were from location 08R010 (Swan Island Lagoon). 2,3,7,8-TCDD TEQ values and total 4,4'-DDT concentrations were relatively consistent at the smallmouth bass locations

Figure 4-32 presents concentrations of selected indicator chemical concentrations for the five smallmouth bass fillet tissue composite samples by river mile fishing zones. Given

the limited number of samples and lack of replicate composites it is not possible to make conclusions about trends in the fillet tissue samples.

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